

Manufactured Chemistry

Rethinking Reactor Design in the Age of Advanced Manufacturing

Addison K Stark

ARPA-E Fellow



$$\frac{\text{Cost}}{\text{Plant Size}} \propto \frac{SA}{V}$$

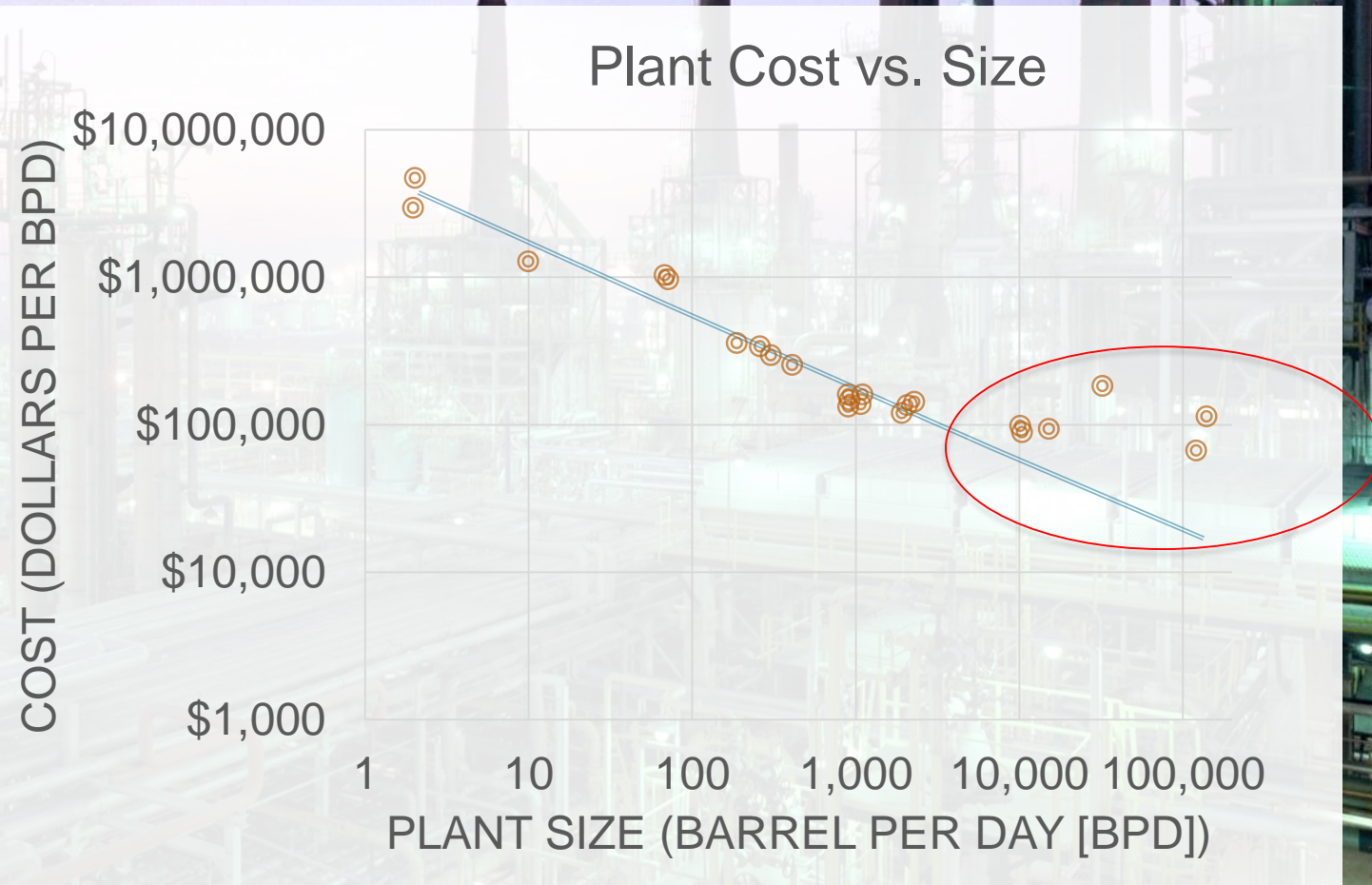
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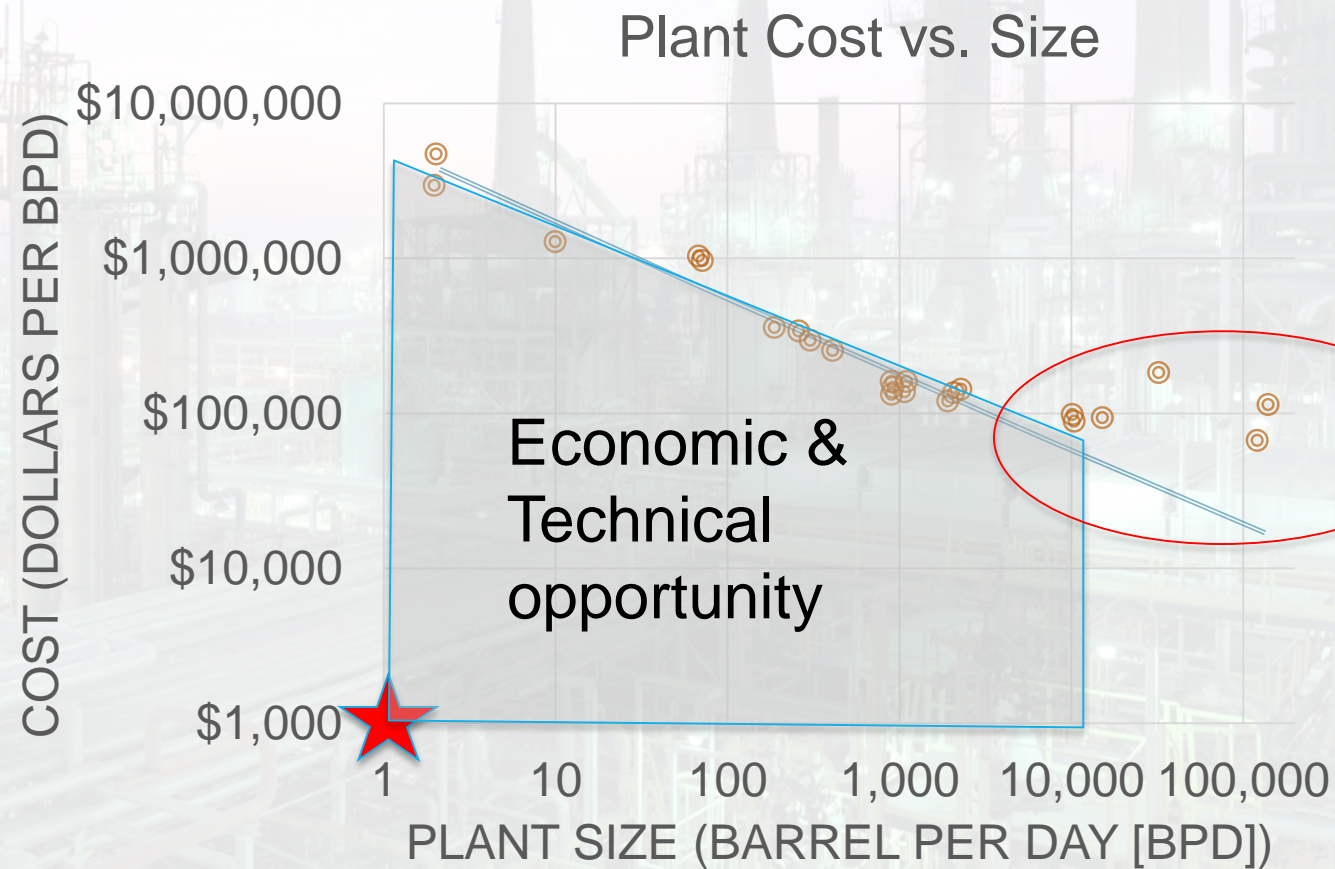
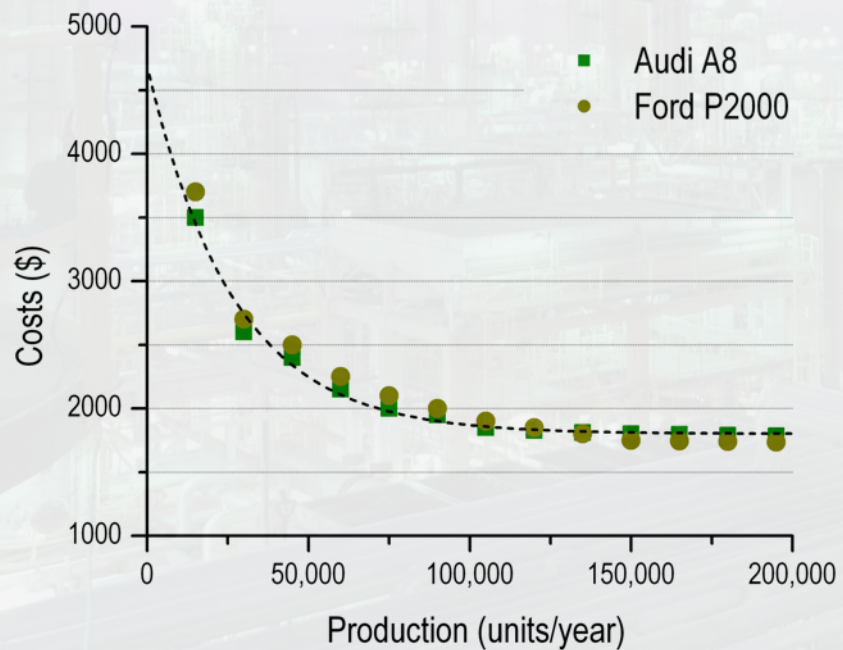
$$\frac{\text{Cost}}{\text{Plant Size}} \propto \frac{2\pi RL}{\pi R^2 L}$$

...

$$\frac{\text{Cost}}{\text{Plant Size}} \propto \frac{2}{R}$$

“Bigger is Better!”







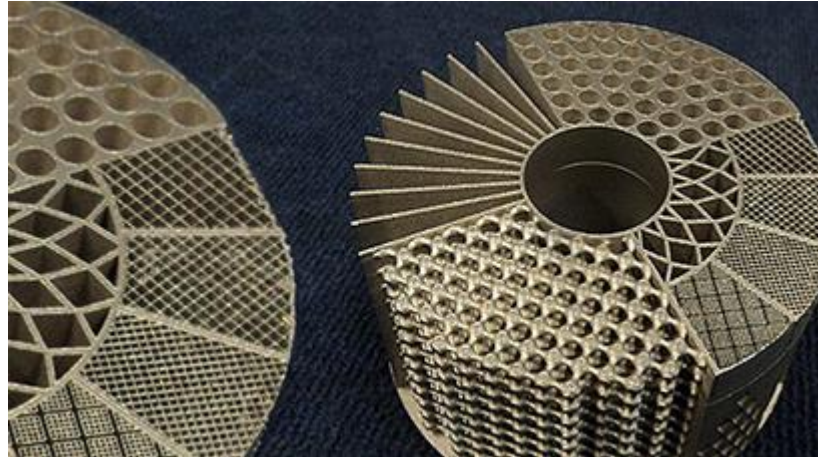
Re-engineering

chemical reactors

... from the ground up

A new reactor design paradigm

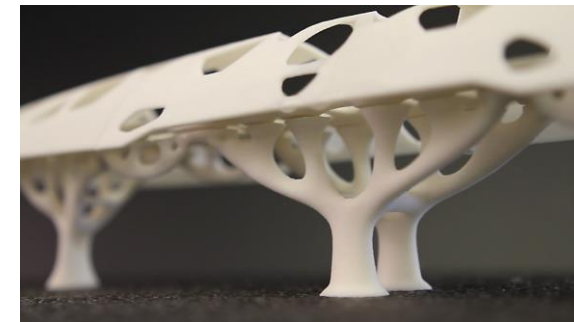
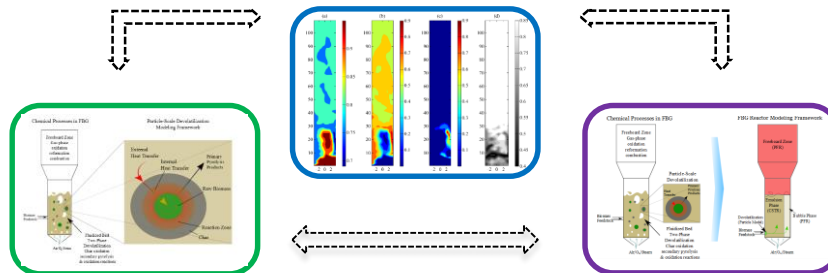
Additive manufacturing



Multi-scale modeling



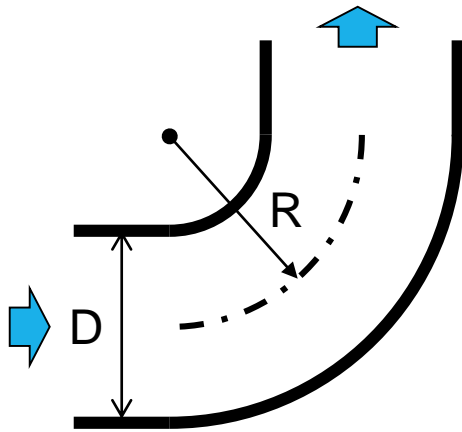
Computational design methods



Computational Design Methods

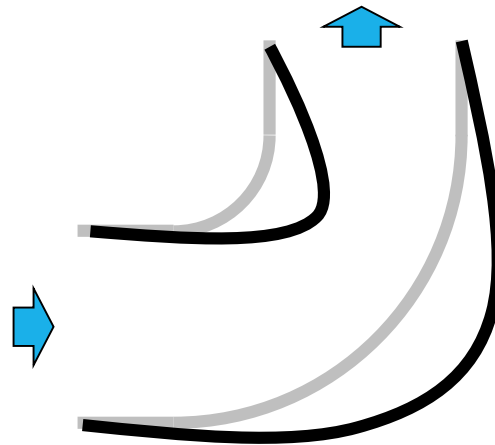
Size optimization

Optimization of dimension(s),
e.g. diameter



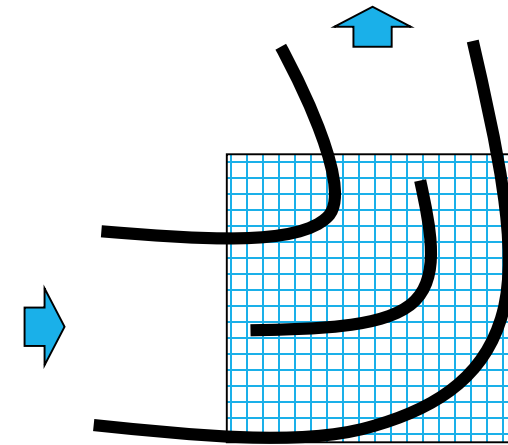
Shape optimization

Boundary represented by
parametric equation and
manipulated

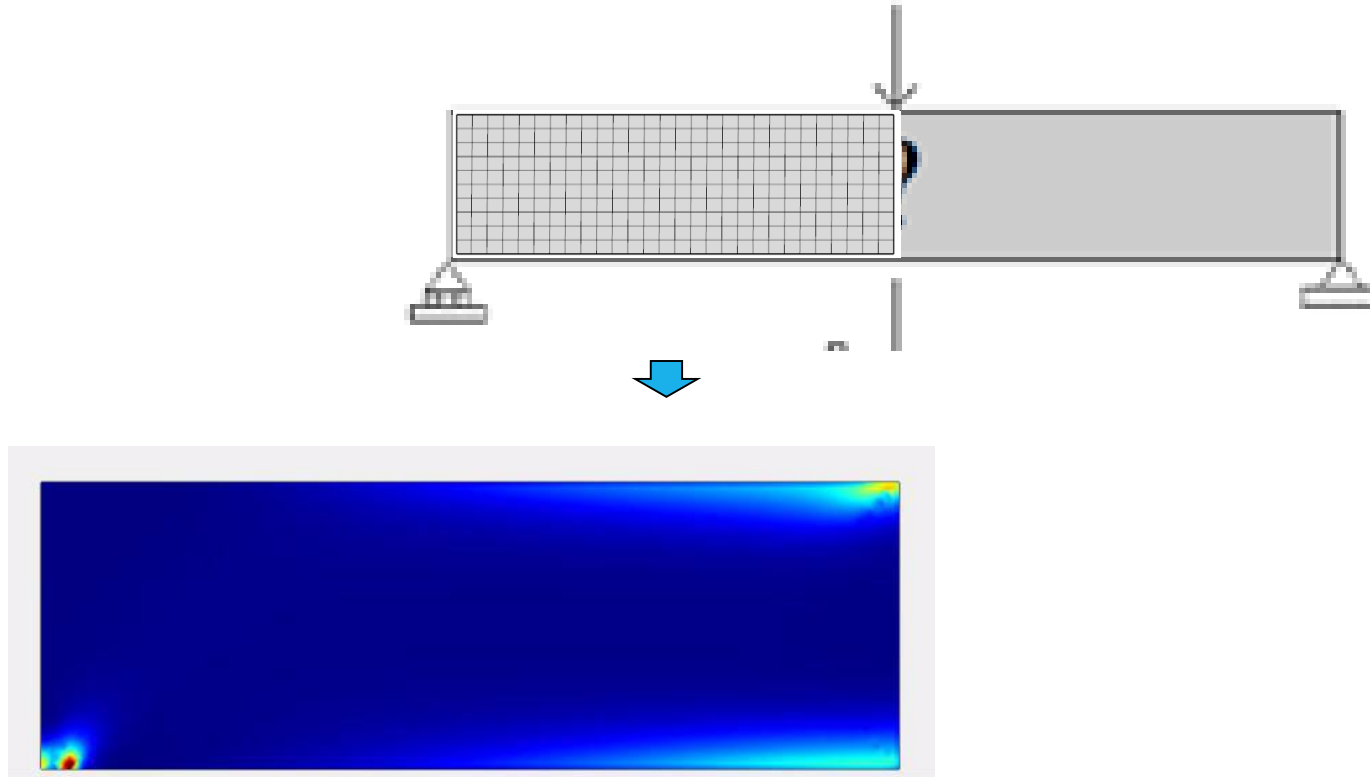


Topology optimization

Introduces new features,
e.g., vanes

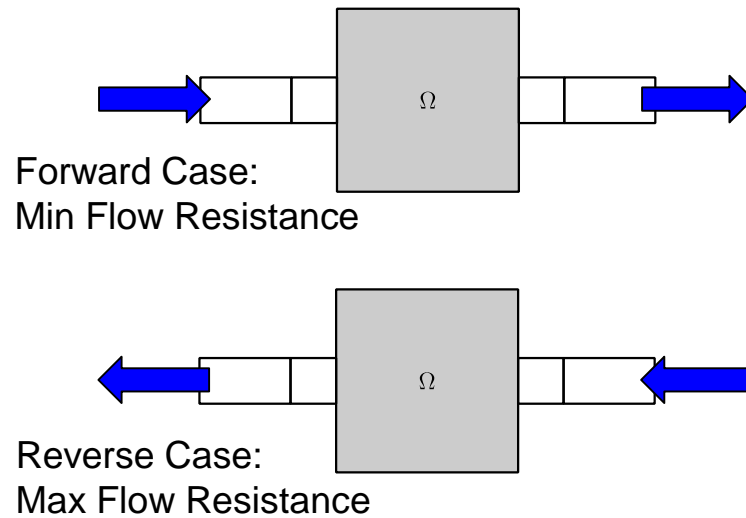


Computational Design: Topology Optimization

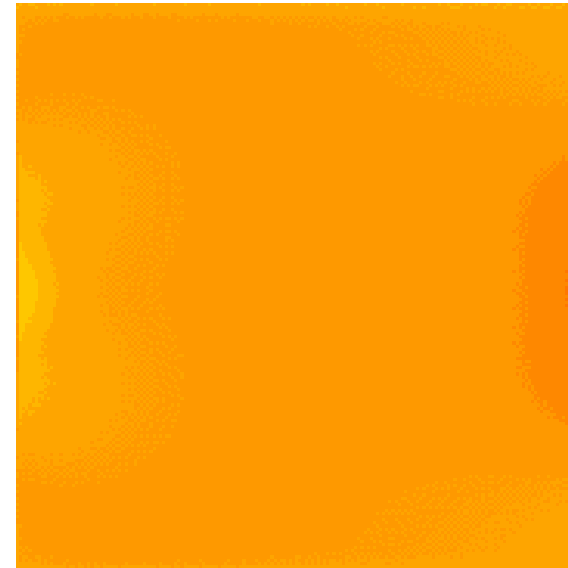


Topology Optimization: Fluidic Diode (Passive Valve)

Design Problem

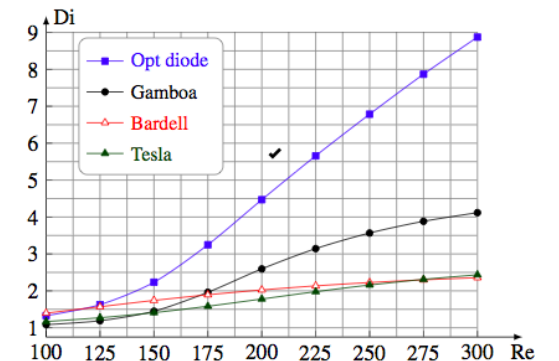
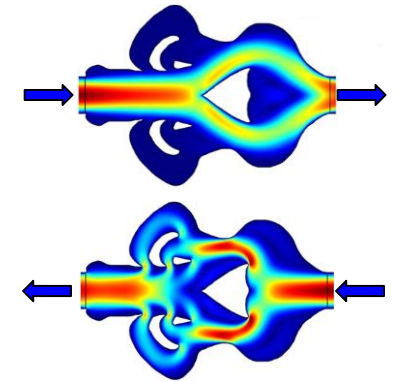


Topology Optimization Evolution



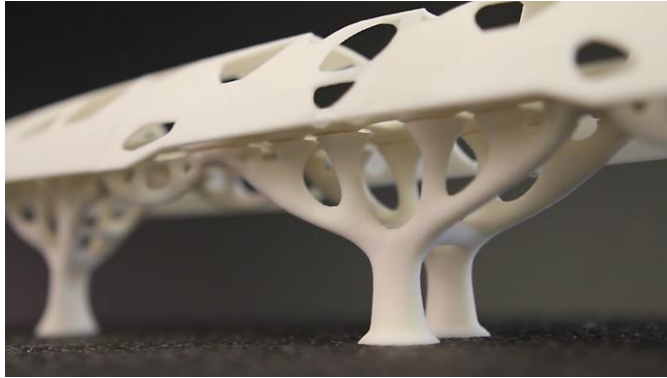
■ = solid
■ = fluid
■ = mixture

Performance



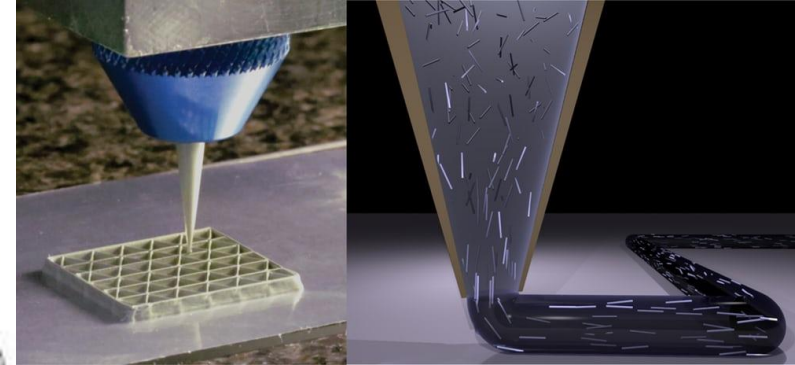
Tomorrow's Reactor Design Opportunities – Enabled by AM

Continuously manufactured complex topologies



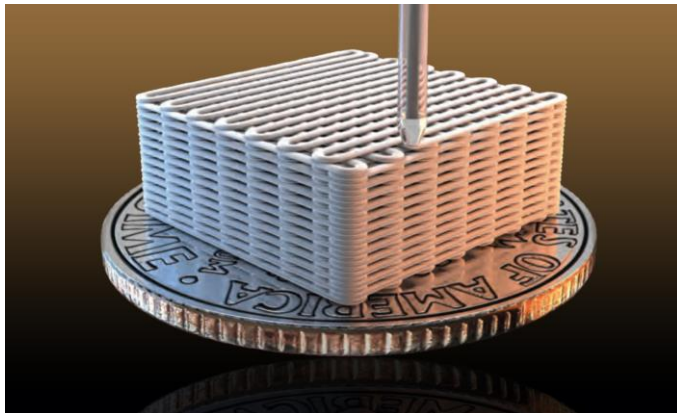
ASME

Printed composites



Harvard

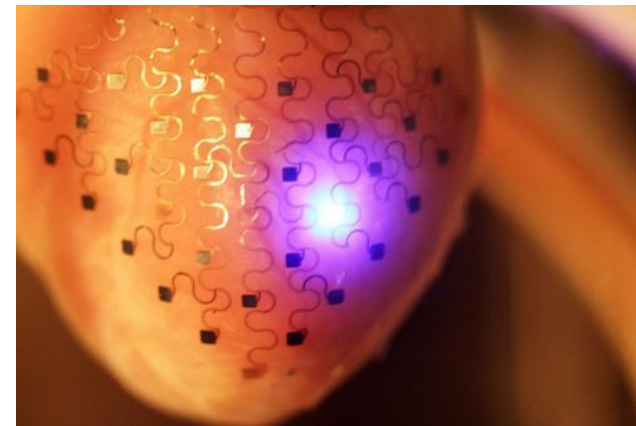
Novel Materials



LLNL, printed aerogel



Printed integrated electronics



WU, STL

